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Evaluation of the assessment of tooth wear by general dental practitioners

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Running title: monitoring tooth wear

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Abstract

Aim: to evaluate currently available methods for assessing and monitoring tooth wear in a general dental practice environment.

Method: A questionnaire was developed and used to obtain data. Models were used to test the dentists' assessment of tooth wear. Ethical permission was obtained.

Results: Twenty general dental practitioners were interviewed and 100% were aware of the use of study models, 50% about the use of photographs and 45% of the BEWE. Methods used to assess and monitor tooth wear were study models (75%), photographs (65%), BEWE (10%), Smith & Knight index (0%) and no method (15%). 65% of dentists were unaware of any guidelines on monitoring tooth wear. Comparing serial photographs: no participant correctly identified all the wear changes and 25% thought a change had occurred when one hadn't. Statistical analysis showed a sensitivity of only 73% with a specificity of 75%. A comparison of serial study models (same cases as used in the photographs): 55% of participants identified a change when no change occurred and 50-60% of participants were able to correctly identify if wear had or had not occurred. Participants graded the models according to BEWE. Statistical analysis of these results shows a sensitivity of just 69% with a specificity of only 55%. The inter-operator agreement (Fliess Kappa) showed an even lower degree of agreement was found with only 0.12 which suggests only a slight level of agreement, less than that with photographs.

Conclusion: Dentists do not seem to be aware of the current guidelines but do make reasonable attempts to monitor tooth wear. None of the currently available methods are ideal and even the use of serial study models is open to much inter-operator variability.

Introduction

The prevalence of tooth wear is high in the adult population and currently in the United Kingdom it is estimated that 77% of dentate adults have some degree of tooth wear exposing the dentine, with 15% of the population having moderate wear and 2% with severe wear.[1] Of particular concern is the significantly increased prevalence recorded by the 2009 UK adult dental health survey compared with 1998 indicating an increase of: 15% for the age group 16-24, 10% for 25 – 34 year olds, 13% for those aged 35 – 44, 7% in the 45 – 54 age group and 4% in the 55 – 64 year olds.[1,2]

Detection and monitoring are important to distinguish between physiological and pathological rates of tooth wear. Methods to do this monitoring in dental practice are limited and tooth wear is often not addressed by dentists until more substantial wear has occurred. There are many suggested methods for assessing and monitoring tooth wear, some more practical and widely accepted than others including:

Colour Measurement assessment of the colour change when enamel is lost.

Quantitative light-induced fluorescence (QLF) using auto-fluorescence of teeth that occurs when a high intensity blue light is shone on the teeth, causing them to emit green light and an image of this is captured on a computer, as a potential means to identify progressive erosive surface loss. There are no studies or applications as yet.[3]

Optical Coherence Tomography (OCT) This method employs measures the intensity of back-scattered light on the tooth tissue surface, similar to ultrasound but using light in place of sound waves.[4] OCT is favoured for accurate measurements of tooth erosion changes in in-vitro studies due to its high degree of accuracy and has also been used in vivo for caries progression studies[4,5] but is difficult to apply clinically.[6]

Optical Reflectometer. One study recently has developed a pen-sized device using the principle of specular reflection intensity[7] to measure the degree of light that is reflected and scattered and can detect early erosive changes.[7,8]

Three-dimensional digital superimposition It is possible to scan study casts and superimposing the digital models of the canines using a reference point.[9] This is a potentially costly method to create models then a 3D scanned image and then analyse them and although the use of a CAD-CAM laser was able to detect changes it was the least sensitive method and not capable of detecting progression.[10.11]

Stereoimagery (photogrammetry). This process using software locates multiple common 3D reference points on two or more 2D images and a complex mathematical relationship to build a digital surface model but unfortunately requires the teeth to be coated or special study cast material used.[12]

Laser profiliometer using a non-contacting laser to scan the outline of the teeth or dental study casts to record the profile of the teeth. Sequential scanning over time can detect changes in the profile[13,14]

Photographs Clinical photographs can be a useful method for assessing changes over a period of time and usually an anterior view, left and right posterior views, and both upper and lower occlusal views are recorded.[15] Photographs may be useful for detecting macro changes over time but is unlikely to show early or slight changes in short periods of time. It is also limited by its 2D nature of a 3D scenario and dentists may under estimate or miss diagnose the extent of tooth wear.[16]

Tooth Wear Indices These at present are often the most favoured method for assessing tooth wear other than study models, as they require no specialist or expensive equipment, nor is there a laboratory fee associated with them. There are a number of indices available, the most commonly used are shown below, all of which aim to quantify or qualify the

amount of tooth tissue lost.[17] With indices that qualify the amount of tooth tissue rather than measure and quantify, the results can be subjective when the examiner has not been properly trained or calibrated to use the scale.[18] Those that quantify tooth wear are often more easily applied using models or in laboratory research than in clinical scenarios where qualitative methods can be more practical.[18] Further complications arise as there is no standardisation of terms across countries when referring to tooth wear, particularly regarding the use of the term "erosion".[18] Indices in use are:

Anterior Clinical Erosive Classification (ACE)

This index devised by Vailati & Belser focuses on the upper anterior teeth and aims to not only grade the severity but also offer restorative decision input.[19] This index is often used in epidemiology and while it gives a very accurate way of monitoring tooth wear long term, it can be complicated to use clinically.

Smith and Knight tooth wear index (TWI)

The TWI[20] was designed to take account of all aetiologies of tooth wear rather than other indices of its time that were specific to a single cause. The main issue with this index is that it focuses on the anterior upper teeth.

Basic Erosive Wear Examination (BEWE)

Its main aim is to be simple to use and demonstrate that tooth wear has been assessed by the clinician and not necessarily to monitor the progression of tooth wear.[21] The index scores the worst affected tooth in the sextant and the total score for the mouth can be used to guide restorative management. Olley et al showed that BEWE was representational of general wear in that sextant although there is the potential for the total score to portray a lower risk then is truly present[22]. The name of the index is deceptive as it suggests it only records tooth wear with an erosive aetiology but it is actually intended to include all forms tooth wear (using the term *erosion* to mean *surface loss* and not specifically limited to *acid erosion*). Similar is the Dental Wear Index (DWI) which describes multifactorial wear and has similar grading criteria to BEWE but does not group scores into sextants.[23]

Study Models remain one of the main clinical methods for monitoring tooth wear over a period of time.[24, 25] They enable to the clinician to keep a series of 3D representations of the mouth at a given time and compare changes that occur. As described previously they can be coupled with 3D scans using contacting (stylus) or non-contacting methods (laser) to record and store these electronically and enable further evaluation.

Silicone indices can be made on the teeth or models and then sectioned according to the area of suspected tooth wear to enable a comparison between appointments.[15]

Flatbed Scanner This method by Van't Spijker et al uses a regular flatbed scanner on which study models are placed with areas of wear highlighted by pen.[26] The total surface area of lesions can be measured to detect changes as well as superimposition of traces. This method is simple and relatively cost but requires the use of models, is time consuming and only provides a 2D assessment. Rodriguez et al compared two-dimensional assessments with three-dimensional assessments.[27]

Using a digital impression scanner to record tooth wear.

The rise in the use of intraoral scanners, some of which are now capable of taking serial intra-oral impression scans and overlaying them to highlight changes in the dentition, has enabled instant analysis and creation of colour-coded areas of change.

Current guidelines for assessing and monitoring tooth wear

There is very little in the way of widely agreed guidelines in the UK for the assessment and monitoring of tooth wear. Recently the Department of Health advised in Delivering Better Oral Health 2017, that BEWE should be used to record and monitor tooth wear along with guidance on the clinical management of the patient.[28] However the Royal College of Surgeons advise clinicians to use photographs, study models or silicone indices to monitor tooth wear, advising that tooth wear indices are not suited to monitoring tooth wear at an individual patient level and are better suited to population epidemiological studies.[29] However there

are problems with the fragility, retention and storage of models. Legislation in England requires practices to retain these models for potentially up to 30 years but for at least 11 years after the patient was last seen, meaning they can only be used for select cases when dealing with established tooth wear, preventing early detection for all patients.[30]

Other concerns and problems in assessing and monitoring tooth wear include:

- Variability between operators when assessing the same patient.
- Variability between visits when assessed by the same operator.
- The accuracy of the methods listed above
- The cost of their implementation both financially and in terms of time.
- Lack of appropriate training / calibration.
- Lack of understanding by GDP's.
- Significant potential for subjective errors.

Given the lack of clear and agreed guidelines in how clinicians should monitor tooth wear this paper aims to assess:

1. Are dentists aware of the current guidelines
2. Do dentists monitor tooth wear & what challenges do they face?
3. Are dentists able to reliably assess & monitor for change in tooth wear?

Methods

Questionnaire

A questionnaire was devised that sought to find out the current level of awareness a group of general dental practitioners had on the assessment and monitoring methods for tooth wear. This questionnaire asked about their current knowledge level of the methods themselves, the guidelines, whether they apply this in practice and what challenges or barriers they face in doing so.

Letters of invitation to participate in the study was sent to a list of dentists obtained from the local LDC in West Sussex as well as GDPs who taught part-time at KCL and 20 responded. DF1 dentists and dentists with specialist qualifications were excluded. The questionnaire was used at the start of the interview session to each dentist then the dentists were then asked to assess a set of simulated cases for presence or absence of active tooth wear. Dentists were provided with five sets of sequential pairs of study models, photos and silicone indices, which were formed from an acrylic casts that were selectively ground to varying degrees (including no change) and locations to simulate attrition and abrasion. This was achieved by preparing the first model of each set and then duplicating this model before applying the required change or no change to duplicate model. It is accepted that examining modified study casts and photographs will not be as realistic as a patient but it is a valid and more practical method to allow dentists to estimate tooth surface loss.

The dentists were asked to identify which photos showed no change in wear or advancing wear and if wear had progressed, where this change was located. Next they were provided with the study models and asked the same question of has there been a change in wear or not, as well as grade the models using the BEWE index (along with a reference card to assist those unfamiliar with the BEWE index).

The models were then scanned using a digital impression scanner Trios 3 Shape to formulate digital study models. The system was then used to compare the matching pairs of models to determine if the system was able to or has the potential to highlight to dentists the tooth wear that had been replicated.

Results

A total of 20 interviews were carried out and 70% were from a mixed practice environment, 20% from a purely NHS background and 10% from a purely private practice. A wide range of experience was covered by this cohort in both terms of the number of years they had been qualified (5 were 1-5 years; 6 were 6-10 years; 3 were 11-15 years and 6 were 20 years or more) and the post-graduation qualification level ranged from none (8), certificate level (4). Diploma level (5) and Masters level (3). The cohort was also from a wide catchment area in the target area which spanned across London, West Sussex and East Sussex all of which are under the control of different NHS teams.

A wide range of knowledge with regards to available methods for assessing tooth wear changes was highlighted by this question. Unsurprisingly all the participants were aware of the use of study models however only 50% knew about the use of photographs and even less knew about the BEWE (45%). Looking further at the data (Figure 1), of the 45% who had heard about the BEWE 60% had qualified in the last 5 years suggesting they had learnt about it at dental school. This suggests that dentists who have been practicing longer than 5 years may not be aware yet of the BEWE despite it being part of the suggested method of recording tooth wear in NHS patients which affects 90% of the cohort.

The most commonly used method for assessing tooth wear was the study models (75%) and photographs (65%). BEWE was used by 10% of those asked with 15% not using any method to assess for tooth wear changes (Figure 2). Regarding BEWE, 60% of the cohort stated they didn't understand it and 35% had never heard of it, across all levels of experience and qualification (Figure 3). None of our cohort used the Smith & Knight method of recording and monitoring tooth wear changes with 45% having never heard of it, 30% not understanding it and 15% saying it was too time consuming.

Unsurprisingly 45% of participants found using silicone indices problematic to store but an equal number had not heard of the technique. Other common barriers included cost (25%), the time to undertake it (15%) and 25% finding it too hard to use or not a useful method.

The participants reported a high concern of the storage of study models (90%), the cost to undertake this (60%) and the time to undertake it (40%). 40% of the participants were also concerned about the models degrading over time and use reducing their accuracy long term.

The final method assessed for barriers was clinical photography (Figure 4) and half of the participants said it took too long to undertake. Further concerns were raised as to the cost or lack of a camera (25%) and a lack of reproducibility to guarantee accuracy (20%). Interestingly this was the only method where some participants felt there were no barriers to undertaking it. Regarding the awareness of guidelines: 65% were unaware of current NHS / Department of Health guidelines and 75% were unaware of the Royal College of Surgeons guidelines for recording tooth wear.

Participants ability to monitor tooth wear by photographs

These results showed that dramatic changes in tooth wear were more easily identified by the participants in the photographs compared to more subtle changes, which is anticipated. More interestingly was that not one participant correctly identified all the wear changes that had occurred in any scenario except photo set five where the changes were buccally placed although they were subtle changes in wear, perhaps due to perception and angulation on a 2D image. Another interesting finding was that 25% of participants thought a change had occurred when one hadn't, possibly due to lack of reproducibility when taking photographs resulting in perceived or artefactual changes due to angulation.

Statistical analysis of these results showed a sensitivity of only 73% with a specificity of 75%, suggesting that ¼ of patients would be potentially miss-diagnosed using this method. Furthermore, the inter-operator agreement (using Fliess Kappa) is only 0.37 which suggests only a fair level of agreement which is very low.

Participants ability to monitor tooth wear by study models and BEWE

A similar trend was noted in the participant's ability to correctly identify if tooth wear had or had not occurred by comparing two sets of study models (Figure 5). The greatest change was more easily identified than more subtle changes but this time nearly half (55%) of participants said some tooth wear had occurred on model three which was a duplicate with no simulated wear (the same as photo three). In all scenarios except model one (the greatest difference), only 50-60% of participants were able to correctly identify if wear had or had not occurred at one or more sites on the arch. In this scenario they were not asked to identify the exact location of the change.

Participants then graded both of the models in each set according to the BEWE (Figures 6). Interestingly in each scenario there was an average variation of 6 gradings for both the pre-wear and post wear models. Also on average only 6-7 participants matched the proposed BEWE although the final scenario (model 5) showed the greatest number of participants matching the proposed grading.

It was also noted that in the cases where the wear was deliberately subtle to avoid a change in BEWE grading, only half of the participant's answers matched this. In scenario four 62% showed no change in wear if the BEWE were compared but the respondent said wear had occurred and 58% in scenario 5 (Figure 7).

Statistical analysis of these results shows a sensitivity of just 69% with a specificity of only 55% again suggesting a large margin of error in diagnosis. Looking at the inter-operator agreement (using Fliess Kappa) an even lower degree of agreement was found with only 0.12 which suggests a slight level of agreement, less than that with photographs.

Discussion

Are dentists aware of the current guidelines & do they monitor tooth wear?

One finding in this limited study is that the majority of the dentists were unaware of the guidelines set out by the RCS and the NHS regarding the monitoring of tooth wear. Furthermore with the NHS recommending the use of the BEWE tool for recording and monitoring tooth wear changes, only 10% of the participants actually used it 'routinely' although we did not assess if this was for all patient or just those once tooth wear has been identified. It is also suggested that newer qualified dentists are more likely to be aware of it although many still did not fully understand how to apply it.

What challenges do they face in monitoring tooth wear?

Most of the dentists were using study models and/or clinical photography to assist them in monitoring tooth wear but expressed a number of barriers, despite these methods being highlighted by the Royal College of Surgeons who suggest this to be the gold standard. The most common barrier was the physical storage of the models with space being a premium for many practices these days as well many practices moving towards digital record keeping. It was also highlighted that models can easily degrade over time and through use, reducing their accuracy long term. The cost of producing the models, typically £18 per set for a laboratory fee, may lead to financial and storage problems for a practice.

An alternative to this is the clinical photography which 65% of the dentists were using as a less costly alternative to study models with the added benefit of easier storage within digital record keeping software. However some dentists reporting access to a camera and the time required to be a difficulty. Two participants in this study also raised the concern that clinical photographs are difficult to compare accurately due to positional and lighting changes.

Are dentists able to reliably assess & monitor for change in Tooth Wear?

When using digital photography, on average only 70% of our participants were able to identify a change in wear had occurred when the progression was subtle and in nearly all scenarios the participants were not able to identify the correct specific sites of wear. Some aspects are less visible on photographs such as palatal wear progression. The sensitivity and

specificity of this test in this study was just 72% and 75% respectively which implies there is a great deal of subjectivity and variation between dentists with diagnosis subject to a high degree of error.

A similar pattern was noted on the use of study models, often suggested as the gold standard. Except where the wear was pronounced, only 60% of participants were able to identify that a change had occurred and where the specific site of change was. This could be overcome by using silicone indices but these were considered not easy to use, can easily be deformed under finger pressure, are costly and present a potential storage issue.

The sensitivity and specificity in this study was lower for models than it was for photographs questioning if study models should still be considered the gold standard. The inter-operator agreement was also lower than that of with photographs raising the same challenges as discussed earlier. These findings should be tested with a larger cohort.

From the results regarding BEWE, there is a large degree of interoperator variability with an average of 6-7 variations of grades. This could be in part be due to a lack of familiarity with the BEWE grading system but research by Dixon et al found a similar conclusion with only a moderate level of inter- and intra- operator reliability.[31] This could raise a concern where in several NHS practices there is a turnover of dentists making on going monitoring inaccurate, or even between visits with the same dentist. A recent publication stated that the BEWE grading tool was never intended for long term monitoring as suggested by the guidelines in delivering better oral health, primarily as there can be an ongoing progression of wear with in the same grading which would not be reflected by the notes, as was seen in our findings in scenario 4 and 5.[32] Instead the tool is intended to help dentists demonstrate they have made an assessment and recorded it, while offering them some form of guidance on the most appropriate treatment to offer at that stage.

It is likely that 3D imaging is capable of overcoming the current barriers presented by the currently available methods but this was not assessed in this study. The level of accuracy

with digital impression systems would lend itself to an earlier warning of pathological tooth wear provided the user is able to differentiate pathological changes from physiological wear. An alternative solution is to have an impression scanned by a 3D imaging machine either on site or at a laboratory but this still presents an element of cost and practicality.

Conclusion

From the current findings there is an indication that the current methods of assessing ongoing tooth wear are limited, lacking accuracy and sensitivity, with the dentist only able to confidently say a change has occurred when the change is significant. Given the slow progressive rate of physiological wear it could be some time before the dentist is aware it has progressed to a pathological rate of wear. This suggests that clinicians should undertake preventive measures at the first sign of mild tooth wear even if we are unsure of its rate of progression and take minimally invasive restorative action where needed. There may be a risk in monitoring patients for many years where the monitoring is inaccurate, risking the patient losing significant tooth tissue before diagnosis is made, complicating the restorative treatment and increasing the cost. The use of digital dentistry through intra oral scanners and appropriate software is likely to be a gold standard in the near future.

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Figures

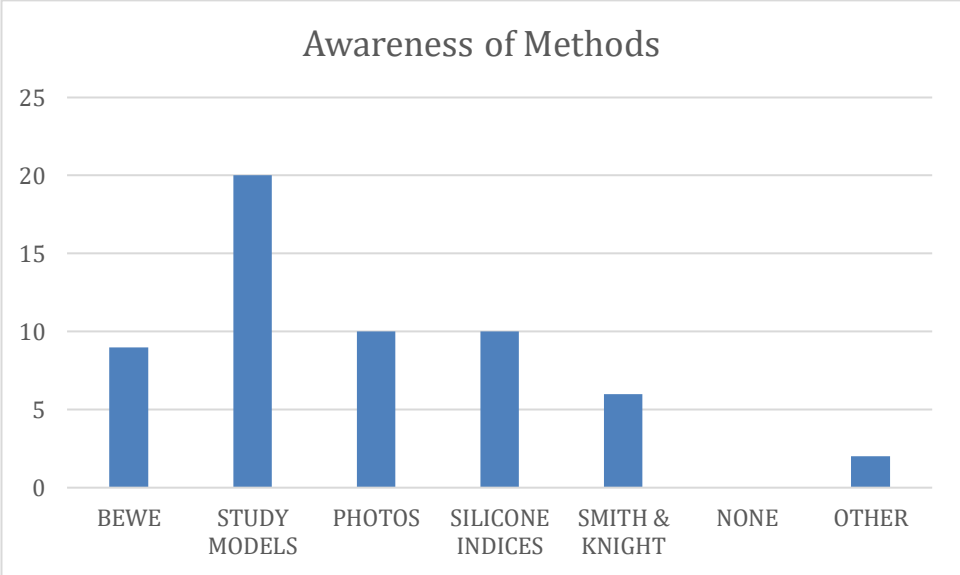

Fig 1 Awareness of methods for recording / assessing toothwear.

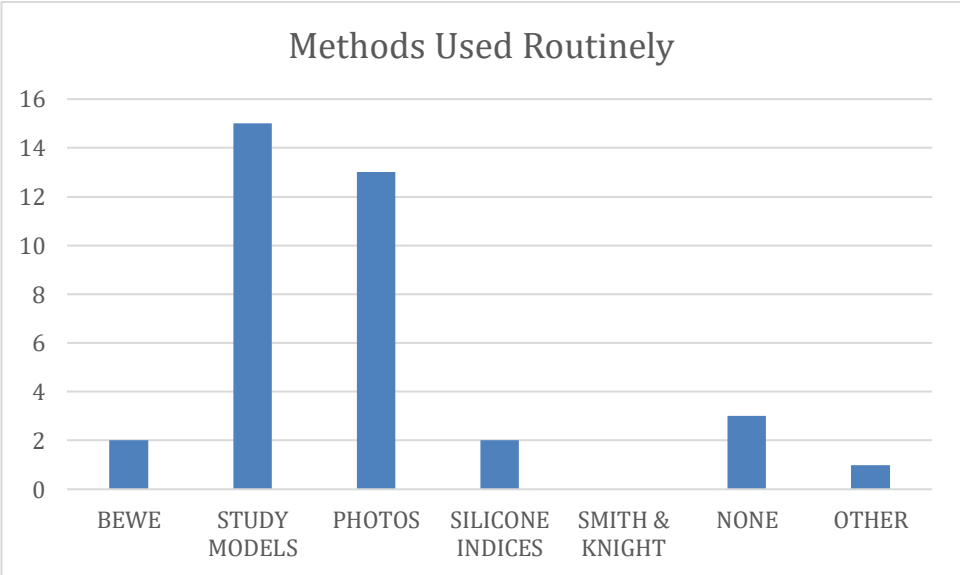

Fig 2 Methods used routinely by participants

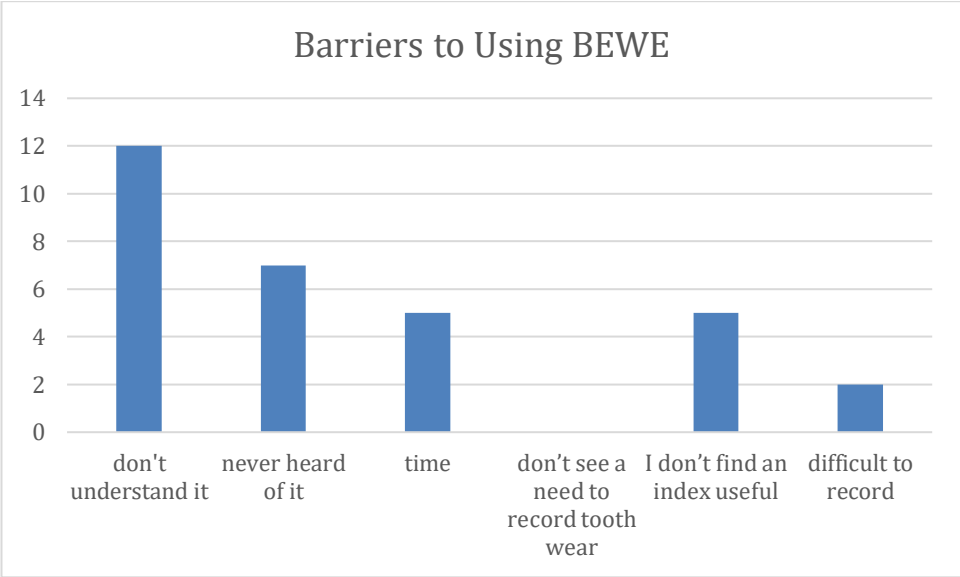

Fig 3 Barriers participants face in using BEWE tool

	Operator perceives a change in TSL	Operator perceives no change in TSL	In reality had a change or no change of TSL occurred?	% of operators correct	ALL correct locations of wear progression identified	Some locations of TSL progression correctly identified	incorrectly identified TSL locations entirely
photo 1	20	0	Yes	**100%**	0	20	0
photo 2	10	10	Yes	**50%**	0	10	0
photo 3	5	15	No	**75%**	0	0	0
photo 4	13	7	Yes	**65%**	0	13	0
photo 5	15	5	Yes	**75%**	5	6	4

Fig 4 Results in relation to assessment of photographs.

	change	no change	change or no change?	% correct
model 1	20	0	yes	**100%**
model 2	10	10	yes	**50%**
model 3	9	11	no	**55%**
model 4	13	7	yes	**65%**
model 5	12	8	yes	**60%**

Fig 5 Results in relation to assessment of study models

	number of variations given (pre)	number of variations given (post)	Matched Proposed BEWE (PRE)	Matched Proposed BEWE (POST)
model 1	7	6	0	2
model 2	7	8	6	4
model 3	6	6	7	7
model 4	7	5	4	8
model 5	5	5	12	12

Fig 6 Variation of results in relation to BEWE

	change in wear identified but no change in BEWE
model one	0
model two	0
model three	0
model four	8
model five	7

Fig 7 Number of cases reporting Change in wear but no change in BEWE score given.